

Some Records on West American Cenozoic Gastropods of the Genus *Aforia*

BY

MAHDOKHT JAVIDPOUR

Isfahan University, Isfahan, Iran

(1 Plate; 2 Text figures)

INTRODUCTION

SIX SPECIES OF THE TURRID gastropod *Aforia* from the west coast of North America define a phylogenetic lineage which is potentially useful in age determination and correlation of the marine Cenozoic of this area. The purpose of this report is to describe and illustrate these species, one of which is new, and to define the morphologic characteristics upon which these species are differentiated.

Aforia appeared during the middle Oligocene on the Pacific margin. *Aforia campbelli* Durham, 1944 is the oldest known fossil record of the genus. The only other Tertiary records are from the Pliocene of Japan (POWELL, 1966). The genus was especially abundant in and characteristic of moderately shallow water strata in middle Tertiary basins of coastal Oregon and Washington (Figure 16).

There are no known occurrences in the middle and the late Miocene, but the genus is represented in the Pliocene of the Gulf of Alaska by *Aforia circinata* (Dall) which ranges today from the Bering Sea to the northwest coast of Washington.

The genus has not previously been monographed, although DURHAM (1944) treated 3 middle Tertiary species from western Washington: *A. campbelli* Durham, *A. clallamensis* (Weaver), and *A. wardi* (Tegland). POWELL (1966) reviewed the modern distribution of *Aforia* in the eastern Pacific, noting that its relatively shallow water occurrences near the equator are an excellent example of "biopolarity". Two of the 4 Oligocene and Miocene species from Washington referred to *Aforia* by POWELL (1966: 44), "*A.*" *borgenae* (Tegland) and "*A.*" *marrowstonensis* (Durham), however, are here regarded as representing different turrid genera.

Species of *Aforia* are particularly useful in correlation of Oligocene and Miocene strata in western Oregon and

Washington where a well-defined phylogenetic sequence is developed (Figure 17).

This lineage is defined upon a number of serial morphologic changes:

- 1) A secondary angulation, or carina, appears at the base of the body whorl in Oligocene and Miocene species, attains its strongest development on the late Oligocene and early Miocene species *Aforia clallamensis* and *A. tricarinata*, but is not developed on the Pliocene to Recent species *A. circinata*.
- 2) The primary angulation is located near the base of the whorls of the spire on the earliest species of *Aforia* but gradually moves toward a medial position in later species.
- 3) The subsutural slope is deeply concave in the oldest species but becomes gradually less so in newer species.
- 4) The position of the growth line sinus is located near the middle of the subsutural slope on the oldest species of *Aforia* but closer to the angulation on the latest species.
- 5) The angulation is sharp in the oldest species but becomes less so in successively younger species.

Aforia may be useful in determining paleobathymetry of Tertiary molluscan assemblages of the west coast of North America. Depth records of *A. circinata* from modern collections in the U. S. National Museum indicate a range of from 34 to 121 fathoms, with almost all of the records deeper than 50 fathoms. Accordingly, fossil occurrences of this genus may be representative of at least outer sublittoral (lower neritic) depths. The modern geographic range of this species from the Bering Sea to the Straits of Juan de Fuca, Washington, indicates association with cool temperate and cold water molluscan faunas.



Figure 16
Index Map of Northwestern Pacific Ocean showing Occurrence
of *Aforia*

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SYSTEMATIC DESCRIPTIONS

Abbreviations for locality description and museum collections used in this section are:

- CAS – California Academy of Sciences, San Francisco, California
 SU – Stanford University, Stanford, California
 SUPTC – Stanford University Paleontological Type Collection, Department of Geology, Stanford, California
 UCMP – University of California Museum of Paleontology, University of California, Berkeley
 USGS – U. S. Geological Survey, Washington, D. C. locality register
 USGSM – U. S. Geological Survey, Menlo Park, California, cenozoic register
 USNM – U. S. National Museum, Washington, D. C.
 UW – University of Washington, Seattle, Washington

GASTROPODA

NEOGASTROPODA

TURRIDAE

Aforia Dall, 1889

Type Species (OD) *Pleurotoma circinata* Dall, 1873.
 Pliocene to Recent.

Recent Range: Bering Sea southeastward to the Straits of Juan de Fuca, Washington.

Diagnosis: Shell large, high spired. Angulation distinct and located near the middle of the whorl. Lower part of whorl sculptured by numerous raised revolving lines, and more clearly, on the body whorl. A second prominent but less well developed angulation often occurs below the primary carina on the body whorl. Growth lines make a deep "V"-shaped sinus about the middle of the subsutural slope. Anterior canal slightly flexed and recurved.

Aforia campbelli Durham, 1944

(Figures 1, 6, 10)

1942 *Aforia clallamensis wardi* (Tegland). WEAVER, Univ. Wash. Publ. Geol. 5: 516 (in part); pl. 97, fig. 10

1944 *Aforia campbelli* Durham. Univ. Calif. Publ. Geol. Sci., Bull. 27 (5): 183; pl. 14, fig. 4

Holotype: UCMP no. 14961

Type Locality: UCMP loc. A-1636. Type "Porter" Bluffs along northeast side of highway beginning at a point 270 yards southeast of first exposure southeast of Porter station and extending 180 yards. Grays Harbor County, Washington, Lincoln Creek Formation; Middle Oligocene.

Description: Shell of moderate size, high spired. Whorls sharply angulated near base. Whorl profile above angulation deeply concave, ornamented by prominent growth lines. These lines constitute a deep, broadly "U"-shaped sinus located somewhat more than half the distance from the suture to the angulation. Lower part of angulation concave, ornamented by several revolving lines that are usually much finer and closer set than on the body whorl. A second strong spiral cord occurs below the angulation on the body whorl. Numerous fine revolving lines occur below the angulation, crossed by very fine longitudinal growth lines. Inner lip with well developed narrow callus. Anterior canal long and slightly inclined to the left.

Measurements of Holotype: height 71 mm; width 23 mm

Discussion: This species differs from *Aforia wardi* by a higher spire and the more concave area above the angulation. The angulation is less acute than on *A. wardi*.

Occurrence: UW locs. A-1603, A-395, A-3299, A-3282, 3314, Porter sec., Lincoln Creek Form. UCMP loc. A-1636 Lincoln Creek Form., Middle Oligocene, Grays Harbor County, Washington; locs. 9003, 9005, 9013, Lincoln Creek Form., Middle Oligocene, Grays Harbor County, Washington. USGS loc. 1895o, Lincoln Creek Form., Thurston County, Washington.

Aforia wardi (Tegland, 1933)

(Figures 11, 14)

1933 *Leucosyrinx clallamensis wardi* Tegland. Univ. Calif. Geol. Sci., Bull. 23 (3): 124; pl. 10, figs. 5-8

1942 *Aforia clallamensis wardi*. WEAVER, Univ. Wash. Publ. Geol. 5: 516; pl. 97, fig. 6

1944 *Aforia wardi*. DURHAM, Univ. Calif. Publ. Geol., Bull. 27 (5): 184

Holotype: CAS no. 5471

Paratypes: UCMP nos. 32204, 32206; SUPTC no. 792

Type Locality: CAS loc. 227, "Bluffs along the east side of the N. P. G. N. and O. W. R. R. tracks at Georgetown", sec. 20, T. 24 N., R. 3 E., King County, Washington. Blakeley Formation, Late Oligocene.

Description: Shell medium sized, whorls strongly angulated. Sutures deeply impressed. Whorl profile between suture and shoulder gently concave, angulated area located near lower third of whorl. Area above angulation ornamented by a series of growth lines, which make a deep sinus at the middle of shoulder. Area below angulation exceedingly concave, ornamented by weak revolving lines. A secondary angulation appears on body whorl, forming a basal keel. There are numerous fine revolving lines on the body whorl. Canal not preserved.

Measurements of Holotype (canal incomplete): height 40 mm; width 23 mm.

Discussion: This species is similar to *Aforia campbelli*, but can be distinguished by the lower spire and the less concave area above the angulation. The angulation is more acute than on *A. campbelli*.

Occurrence: UW locs. B-0356, B-0357, Middle fork Satsop River sec., Lincoln Creek Form.; UW loc. B-0273 Canyon River sec., Lincoln Creek Form. CAS loc. 227, Blakeley Form., Georgetown, Washington; UCMP locs. 681, 1804, A-8724, Blakeley Form., U. Oligocene, Kitsap County, Washington, loc. A-1806, Blakeley Form., U. Oligocene, Bainbridge Island, Kitsap County, Washington; Loc. F-17 (RAU, 1966), Lincoln Creek Form., Grays Harbor County, Washington. USGS loc. M-2589, Lincoln Creek Form., Wahkiakum County, Washington; loc. M-4043, Blakeley Form., Upper Oligocene, Kitsap County, Washington.

Plate Explanation

Figure 1: *Aforia campbelli* Durham. U.C.M.P. 10786; loc. 9003. Height (incomplete) 21 mm, width 8 mm. Lincoln Creek Formation, Middle Oligocene. Grays Harbor County, Washington. $\times 1\frac{1}{2}$

Figures 2, 7: *Aforia clallamensis* (Weaver). U.S.N.M. 646831. U.S.G.S. loc. M-4038. Height (incomplete) 39 mm, width 16 mm. Upper part of Twin River Formation, Oligocene or Miocene. Clallam County, Washington.

Figure 3: *Aforia circinata* (Dall). U.S.N.M. 646838. U.S.G.S. loc. M-4392. Height (incomplete) 28 mm, width 9 mm. Tugidak Formation, Pliocene. Tugidak Island, Alaska.

Figure 4: *Pseudoperissolax merriami* Clark. Paratype. U.C.M.P. 11286. U.C.M.P. loc. 3055. Height 37 mm, width 22 mm. Kirker Tuff, Oligocene or Miocene. Contra Costa County, California.

Figure 5: "*Aforia*" *packardi* (Weaver). Holotype. C.A.S. 473. C.A.S. loc. 256. Height 24 mm, width 11 mm. Lincoln Creek Formation, Oligocene. Lewis County, Washington.

Figure 6: *Aforia campbelli* Durham. U.S.N.M. 64682. U.S.G.S. loc. 1895. Height 19 mm, width 6 mm. Lincoln Creek Formation, Middle Oligocene. Grays Harbor County, Washington. $\times 2$

Figure 8: *Aforia addicotti* Javidpour, spec. nov. U.S.N.M. 646834. U.S.G.S. loc. M-3191. Height (incomplete) 50 mm, width 25 mm. Siltstone of Alsea Formation, Upper Oligocene, Lincoln County, Oregon.

Figure 9: *Aforia circinata* (Dall). S.U.P.T.C. 10057. Height 53 mm, width 26 mm. Recent. Kodiak Island, Alaska.

Figure 10: *Aforia campbelli* Durham. Holotype. U.C.M.P. 14961. U.C.M.P. loc. 1636. Height 60 mm, width 18 mm. Lincoln Creek Formation, Middle Oligocene. Grays Harbor, Washington.

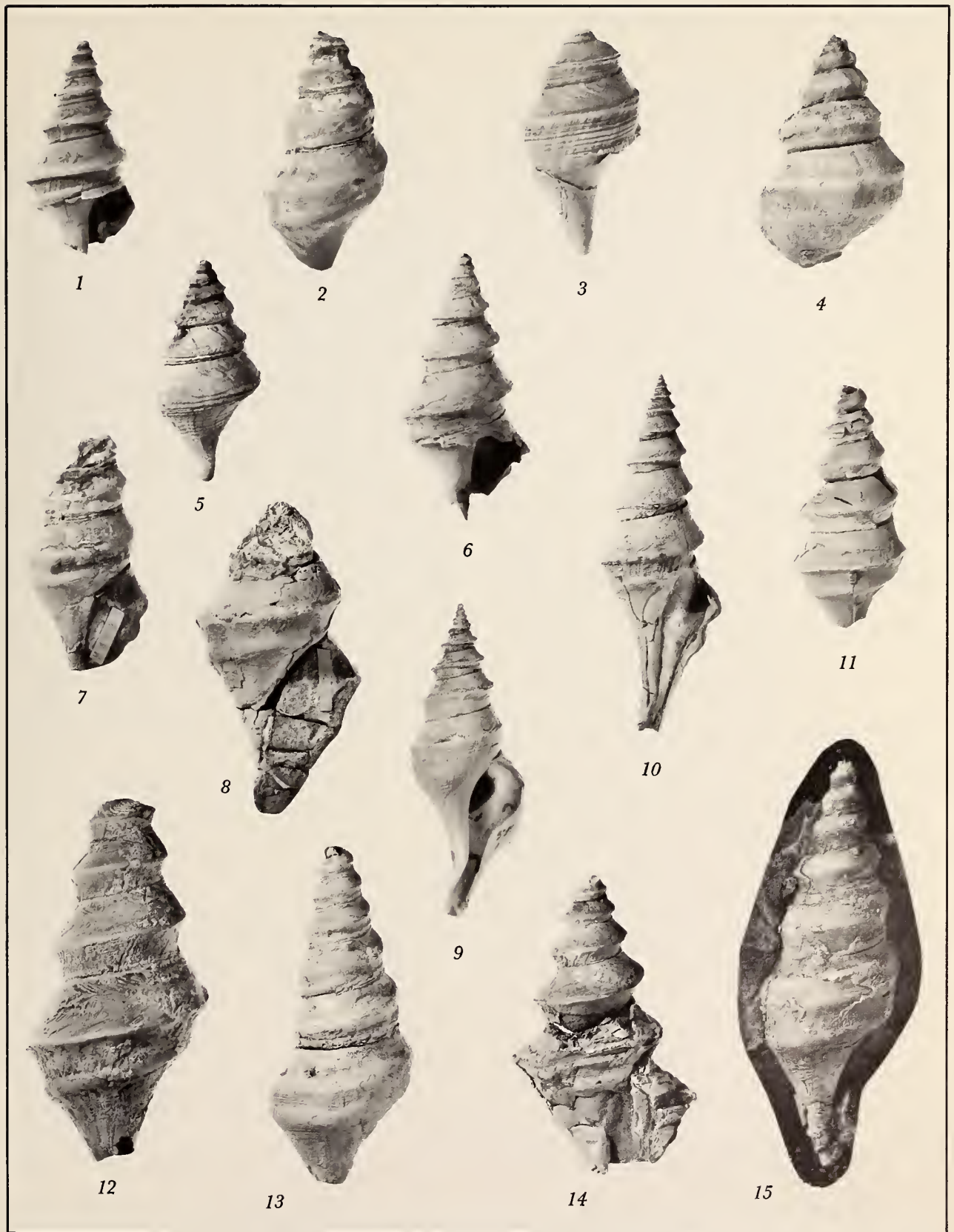
Figure 11: *Aforia wardi* (Tegland). U.C.M.P. 10787. U.C.M.P. loc. 681. Height 39 mm, width 18 mm. Blakeley Formation, Upper Oligocene. Bainbridge Island, Kitsap County, Washington.

Figure 12: *Aforia addicotti* Javidpour, spec. nov. Holotype. U.W. Burke Memorial Museum 60600 U.W. loc. B0058. Height (incomplete) 62 mm, width 30 mm. Siltstone of Alsea, Upper Oligocene. Lincoln County, Oregon.

Figure 13: *Aforia clallamensis* (Weaver). U.S.N.M. 646832. U.S.G.S. loc. 4090. Height 56 mm, width 22 mm. Twin River Formation, Oligocene or Miocene. Clallam County, Washington.

Figure 14: *Aforia wardi* (Tegland). Holotype. C.A.S. 5471. C.A.S. loc. 227. Height 40 mm, width 23 mm. Blakeley Formation, Upper Oligocene. Georgetown, Washington.

Figure 15: *Aforia tricarinata* Addicott. U.S.N.M. 649126. U.S.G.S. loc. 15329. Height 68 mm, width 25 mm. Yaquina Formation, Lower Miocene. Lincoln County, Oregon.



Aforia addicotti Javidpour, spec. nov.

(Figures 8, 12)

Holotype: U. W. Burke Memorial Museum no. 60600

Type Locality: UW loc. B0058. Siltstone of Alsea, Upper Oligocene.

Description: Shell large and heavy. Sutures deeply impressed. Spire high. Periphery of spire and body whorl sharply angulated. Angulation occurs below middle of whorls of spire. Surface above angulation straight to slightly concave, ornamented by numerous growth lines that make deep sinus located just below the middle of the subsutural slope. Area below angulation concave, ornamented by about 12 revolving lines. A second strong spiral cord appears on the body whorl below the primary angulation. Body whorl ornamented by numerous revolving lines and much weaker longitudinal lines. Canal straight and very long. Inner lip smooth. Aperture calloused.

Measurement of Holotype: height, incomplete, 62 mm, width 30 mm

Discussion: In shape and appearance this species is similar to *Aforia wardi*. The angulation is near the middle of the whorl, relatively higher than on *A. wardi*. The area below the angulation is much less concave on the new species and the angulation is sharper on *A. wardi*.

Occurrence: U. W. Burke Memorial Mus. loc. B 0058. Siltstone of Alsea, Toledo Quarry, Yaquina Bay, Oregon. USGS locs. M-1979, M-3191, Siltstone of Alsea, Upper Oligocene.

Aforia clallamensis (Weaver, 1916)

(Figures 2, 4, 7, 13)

- 1916 *Turris clallamensis* Weaver. Univ. Wash. Publ. Geol. 1: 52; plt. 4, fig. 59
 1918 *Pseudoperissolax merriami* Clark. Univ. Calif. Publ. Geol. Bull. 11 (2): 181; plt. 21, fig. 4 [not plt. 22, figs. 10, 15]
 1933 *Leucosyrinx clallamensis*. TEGLAND, Univ. Calif. Publ. Geol. Bull. 23 (3): 123-124; plt. 10, figs. 3, 4
 1942 *Aforia clallamensis*. WEAVER, Univ. Wash. Publ. Geol. 5: 516; plt. 97, fig. 1
 1944 *Aforia clallamensis*. DURHAM, Univ. Calif. Publ. Geol. Bull. 27 (5): 184
 1963 *Aforia clallamensis*. MOORE, U. S. Geol. Survey Prof. Paper 419: 47; plt. 10, figs. 16, 18
 1966 *Aforia clallamensis*. ADDICOTT, Journ. Paleont. 40 (3): 641; plt. 76, figs. 10, 11

Holotype: CAS no. 555

Type Locality: UW loc. 258, sea cliff one-half mile west of Twin River, in sec. 22, T. 31 N. R. 10 W., Clallam County, Washington. Upper part of Twin River Formation, Late Oligocene or Early Miocene.

Description: Shell large, whorls of spire with distinct angulation located a little below the central portion of each whorl. Surface of whorls above angulation slightly concave, ornamented by numerous growth lines which make a deep sinus located somewhat above the middle of the subsutural slope. Faint longitudinal growth lines occur below the angulation and, more clearly, on the body whorl. A second prominent but less well developed angulation occurs below the primary carina on the body whorl and on the penultimate whorl. Aperture narrow and calloused. Canal straight. Inner lip smooth.

Measurement of Holotype: height 66 mm, width 28 mm

Discussion: *Aforia clallamensis* (Weaver) is similar to *A. wardi* (Tegland) but differs by having a less sharp angulation and also less concave surface above the angulation. The profile of the body whorl is straight on *A. clallamensis* but concave on *A. wardi*.

Poorly preserved specimens that may represent *Aforia clallamensis* occur in a collection from UCMP loc. A-1806, together with at least one specimen that is clearly *A. wardi*. The lower angulation on the penultimate whorl of these specimens is extremely weak. They are doubtfully identified as *Aforia* cf. *A. clallamensis*.

Occurrence: UW loc. 258, Twin River Form., Clallam County, Washington, loc. 489, Twin River Form., Washington; loc. 271, Twin River Form., Washington. UCMP loc. A-3677, Twin River Form., Upper Oligocene, Clallam County, Washington, loc. A-6, Twin River Form., Oligocene, Clallam County, Washington, loc. 3055, Kirker Tuff, Contra Costa County, California. SU label no. 3024, Twin River Form., Oligocene, Clallam County, Washington. USGS loc. M-2120, Nye mudstone, Lincoln County, Oregon, loc. M-4038, Twin River Form., Clallam County, Washington, loc. 4090, Twin River Form., Oligocene or Miocene, Clallam County, Washington.

Aforia tricarinata Addicott, 1966

(Figure 15)

- 1966 *Aforia clallamensis tricarinata* Addicott. Journ. Paleont. 40 (3): 641; plt. 76, figs. 9, 12, 13

Holotype: USNM no. 649125, a rubber cast

Type Locality: USGS Cenozoic loc. M-1990 in NE $\frac{1}{4}$ sec.

4, T. 11, S. R. 11 W, Yaquina quadrangle, Lincoln County, Oregon. Nye Mudstone, Early Miocene.

Original Description: Large, fusiform, with seven whorls on incomplete type specimen. Whorls angulated near midpoint by coarse spiral cords, profile convex above and concave below. Upper half of later whorls with a centrally located broad spiral band; lower half with similar band located immediately above suture. Alternating spiral threads of secondary and tertiary strength occur on later whorls below medial carina. Suture collared, impressed. Body whorl and spire incomplete. Very fine growth lines indicate a sinus located near posterior quarter line on later whorls.

Measurements of Holotype: height (incomplete) 45 mm, width (incomplete) 20 mm

Discussion: *Aforia tricarinata* is closely related to *A. clallamensis* but differs in having a prominent spiral cord between the suture and the primary angulation on all but the earliest whorls.

Occurrence: USGS Cenozoic locs. 21806, M-1990, and M-3630, Nye Mudstone. USGS loc. 15329, upper part of Yaquina Form., and USGS locs. 2755 and 18907a, stratigraphic position doubtful, Lincoln County, Oregon.

Aforia circinata (Dall, 1873)

(Figures 3, 9)

- 1873 *Pleurotoma circinata* Dall. Calif. Acad. Sci. Proc. 5: 4; pl. 2, fig. 5
 1902 *Pleurotoma circinata*. DALL, Proc. U. S. Nat. Mus. 24 (1264): 515; pl. 36, fig. 1
 1921 *Aforia circinata*. DALL, U. S. Nat. Mus. Bull. 112: 68; pl. 11, fig. 6
 1927 *Aforia circinata*. OLDROYD, Stanford Univ. Publ. Geol. Sci. 2 (1): 63; pl. 4, fig. 1
 1966 *Aforia circinata*. POWELL, Bull. Auckland Mus. no. 5: 43; pl. 5, fig. 12

Type Locality: Nateekin Bay, Captain's Bay, Unalaska. Recent.

Description: Shell thin, fusiform, with high spire and angulated whorls. Angulation located near the middle of the whorl. Growth lines make a deep "U"-shaped sinus on the lower half of the subsutural slope. Whorl profile above angulation slightly concave. Lower part of whorl sculptured by numerous raised revolving lines. Body whorl slightly shorter than spire, ornamented by numerous revolving lines which are crossed by alternately heavier and finer longitudinal lines. Aperture ovate, canal long and inclined to the left.

Discussion: This species differs from the Oligocene and Miocene species of *Aforia* in having a thin shell, a recurved anterior canal, and in lacking a secondary angulation on the body whorl. On some of the Recent specimens from Alaska, however, a poorly developed anterior angulation appears on the final quarter turn of the body whorl. The angulation is located almost on the central part of each whorl. Pliocene specimens from Alaska have a deep sinus that is located closer to the angulation than in modern specimens.

Occurrence: Recent: USNM locs. 225566, 225586, 211-973, 222525, 222483, 222495, 209710, 130511, 222958, Pribiloff Islands, Bering Sea, 34 to 121 fathoms; locs. 211-979, 211980, 206086, 209729, Unalaska, Aleutian Islands, 68 to 85 fathoms; loc. 222303, Numiak Island, Aleutian Islands, 85 fathoms; loc. 223933, off Unalaska, Aleutian Islands, 78 fathoms; loc. 211974, 223100, 211978, Unimak Island, Aleutian Islands, 60 to 81 fathoms; loc. 210158, Bering Sea, 62 fathoms; locs. 224079, 224246, 223879, 224218, 223174, 224429, 224633, off Pribiloff Islands, Bering Sea, 49 to 86 fathoms. Recent: SU loc. 51982, Bristol Bay, Alaska, 49 fathoms. Pliocene: USGS loc. M-2522, Yakataga Form., Middleton Island, Alaska; loc. M-4272, Gulf of Alaska; locs. M-4394, M-4392, M-4402, Tugidak Island, Alaska.

"*Aforia*" *packardi* (Weaver, 1916)

- 1916 *Turris packardi* Weaver. Univ. Wash. Geol. 1 (1): 55; pl. 5, fig. 64
 1916 *Turris packardi*. WEAVER, Wash. Geol. Surv. Bull. 13: 313
 1942 *Aforia packardi*. WEAVER, Univ. Wash. Publ. Geol. 5: 516; pl. 97, fig. 3
 1944 "*Aforia*" *packardi*. DURHAM, Univ. Calif. Publ. Geol. Bull. 27 (5): 184

Holotype: CAS no. 473

Type Locality: UW loc. 256 in railway cuts on the O. W. R. R. and N. Co. One-fourth mile northwest of Galvin Station in sec. 27, T. 15 N., R. 3W, Lewis County, Washington, Lincoln Creek Formation, Oligocene.

Description: Shell small and pagodaform, whorls of spire strongly angulated near base. Two strong spiral cords located on the angulation of each whorl. Area above angulation somewhat concave, ornamented by 7-9 very faint revolving lines. Axial lines of growth prominent, forming a shallow sinus near base of whorls of the spire. Surface below angulation slightly concave, sculptured with about four faint revolving lines. Body whorl sculptured by about 22 prominent revolving lines below the angulation, and numerous faint longitudinal lines. Inner lip smooth, outer

lip with sharp angulation. Canal deep, medium in length, inclined slightly to the left.

Measurements of Holotype: height 24 mm, width 11 mm

Discussion: This small species is distinguished by its pagodaform spire, and, especially, by having 2 spiral cords on the angulated area. But as DURHAM (1944: 184) mentioned, reference of this species to *Aforia* is questionable because the turrid notch is broad, not very deep, and its lower border crosses over the angulation.

Occurrence: UW loc. 256, Lincoln Creek Form., Lewis County, Washington; locs. A-575, A-52, Porter sec., Lincoln Creek Form. UCMP loc. T. 8, Lincoln Creek Form., Oligocene, Grays Harbor County, Washington. USGS Cenozoic loc. 18974, Lincoln Creek Form., Oligocene, Grays Harbor County, Washington; loc. M 1729, Lincoln Creek Form., Porter Bluffs, western Washington.

LOCALITY DESCRIPTIONS

C. A. S. California Academy of Sciences

loc. 227

Upper Oligocene, Blakeley Formation. "Bluffs along the east side of the N. P. G. N. and O. W. R. R. tracks at Georgetown."

S. U. Stanford University

3024

Oligocene or Miocene. Twin River Formation. Clallam County, Washington.

cat. no. 51982

Recent. Bristol Bay, Alaska, 49 fathoms, 55°20' N, 164°00' W.

U. C. M. P. University of California, Museum of Paleontology

loc. A-6

Oligocene or Miocene. Twin River Formation, Clallam County, Washington. Shale cliffs in first large embayment east of East Twin River.

loc T-8

Oligocene. Lincoln Creek Formation, Grays Harbor County, Washington. (*Turritella porterensis* and *Exilia lincolnensis* occur in the collection.)

loc. A-1636

Middle Oligocene. Lincoln Creek Formation, Grays Harbor County, Washington. Type "Porter" Bluffs along northeast side of highway beginning at a point 270 yards southeast of first exposure southeast of Porter station and extending 180 yards.

loc. A-3677

Oligocene or Miocene. Twin River Formation, Clallam County, Washington. In shale exposed in sea cliff. About in center of north line of the S. W. $\frac{1}{4}$ of sec. 23, T. 31 N, R. 10W.

loc. 681

Upper Oligocene. Blakeley Formation, Bainbridge Island, Kitsap County, Washington. Generalized locality for fossiliferous strata around Restoration Point.

loc. 1804

Upper Oligocene. Blakeley Formation, Kitsap County, Washington. Conglomerate on south side of Bremerton Inlet, Middle point. Sec. 15, T. 24 N., R. 2E.

loc. A-1806

Upper Oligocene. Blakeley Formation, Bainbridge Island. Kitsap County, Washington. From the sandstone at Restoration Point. Eastern boundary of section 12, T. 24 N., R. 2E.

loc. 3055

Oligocene or Miocene. In valley north of Sobrante Ridge, on west fork of Bear Creek $\frac{1}{2}$ mile from source, on north bank in Tuff beds, elevation 800 feet, Contra Costa County, California. Long. 122°12'35" W, lat. 37°55'58" N.

loc. 9003

Middle Oligocene. Lincoln Creek Formation, Grays Harbor County, Washington. Clemons Logging R. R. 420 - 500 paces northwest of Saginaw Trail, Sec. 6, T. 16N., R. 6W.

loc. 9005

Oligocene. Lincoln Creek Formation, Grays Harbor County, Washington. Sec. 6, T. 16 N, R. 6W, M. loc. 5', Clemons Logging R. R. 1050 - 1100 paces northwest of Saginaw Trail in the NW $\frac{1}{4}$ of sec. 6.

loc. 9013

Middle Oligocene, Lincoln Creek Formation, Grays Harbor County, Washington. Clemons Logging R. R. 1200 - 1300 paces northwest of Saginaw Trail.

RAU (1966)

loc. F17

Upper Oligocene. Lincoln Creek Formation, Grays Harbor County, Washington. West fork of Satsop River, 1500 feet north, 400 feet west of S. E. cor. sec. 21, T. 21 N., R. 7W.

U. S. G. S. United States Geological Survey, Washington, D. C., register

loc. 1895

Middle Oligocene. Lincoln Creek Formation, Grays Harbor quadrangle, Washington. Highway south of Porter 4750 feet east, 3510 feet north of S. W. cor. sec. 28, T. 17 N., R. 5 W. Malone quadrangle.

loc. 4090

Oligocene or Miocene. Twin River Formation, Clallam County, Washington. Lake Crescent, 15 quad. Sea Cliff exposure, west of mouth of West Twin River. Upper part of Twin River Formation.

loc. 15329

Middle Oligocene. Yaquina Formation, Lincoln County, Oregon. Fossils from concretions on shore of Yaquina Bay. N W. $\frac{1}{4}$, N. E. $\frac{1}{4}$ sec. 15, T. 11S, R. 11W.

U. S. G. S. United States Geological Survey, Menlo Park, California, register

loc. 18974

Oligocene. Lincoln Creek Formation, Grays Harbor County, Washington. Grays Harbor quadrangle. Clemons Logging road 3750 feet east, 1750 feet north of S. W. corner sec. 25, T. 17N., R. 7W. Montesano quadrangle WN.

loc. M-1729

Oligocene. Lincoln Creek Formation, Grays Harbor County, Washington.